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US CRUISE REPORT FOR BIE I

JULY 17 - AUGUST 23, 1991

R/V YUZHMORGEOLOGIYA

by

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Introduction

The resuspension of sediment by manganese nodule mining is predicted to impact benthic communities in the abyssal seafloor. However, the extent of this impact and its relation to the thickness of the sediment redeposition layer is not currently known. It is hypothesized that abyssal benthic organisms will be affected by resedimentation either through sediment burial or food resource dilution. The need to address this problem before commercial mining commences on the abyssal plane has led to the development of the Benthic Impact Experiment (BIE) project.

The BIE project is designed to assess the potential environmental effects of sediment redeposition from deep ocean mining on the abyssal benthic communities. In this study, a large area of the deep-sea floor is being blanketed with sediment in a manner simulating deep-sea manganese-nodule mining activity. The response of the deep-sea benthic community to different levels of sediment burial will then be monitored both spatially and temporally. The results of this research effort will be used by NOAA to evaluate the terms, conditions and restrictions for commercial permitting by the deep seabed mining consortia so that mining can proceed in a environmentally sound manner.

The Benthic Impact Experiment (BIE) expedition, C. S. Smith and D. D. Trueblood co-chief scientists, was sponsored by the National Oceanic and Atmospheric Administration's Ocean Minerals and Energy Division (Sea Grant No. NA89AA-D-SG063, C. S. Smith). This study is being carried out in collaboration with soviet scientists from the Ministry of Geology aboard the R/V YUZHMORGEOLOGIYA. Also invited to participate are scientists from Germany, France and Japan.

There are four phases in the BIE project. The first phase involved the design and testing of the Deep Sea Sediment Resuspension System (DSSRS). The DSSRS was conceived by NOAA scientists and is a critical piece of equipment for simulating a mining disturbance (Fig. 1). On June 10-20, 1991 NOAA successfully tested the DSSRS at a depth of 4000 m on the Patton Escarpment off the California coast. The success of DSSRS demonstrated that relatively large scale mining disturbances could be experimentally simulated allowing the direct evaluation of potential mining impacts on benthic community structure.

The second phase of the BIE project, June 24 - July 14, 1991, took place in the near-equatorial North Pacific Ocean in an area designated as a Provisional Reference Area (PRA). This area was chosen for conducting the BIE project because 2 years of current meter data had been collected in this area, detailed Seabeam bathymetry was known for this area and the PRA was located in an area near established US and Russian mining claims. Phase two of

THE DEEP-SEA SEDIMENT RESUSPENSION SYSTEM (DSSRS) FOR THE BENTHIC IMPACT EXPERIMENT

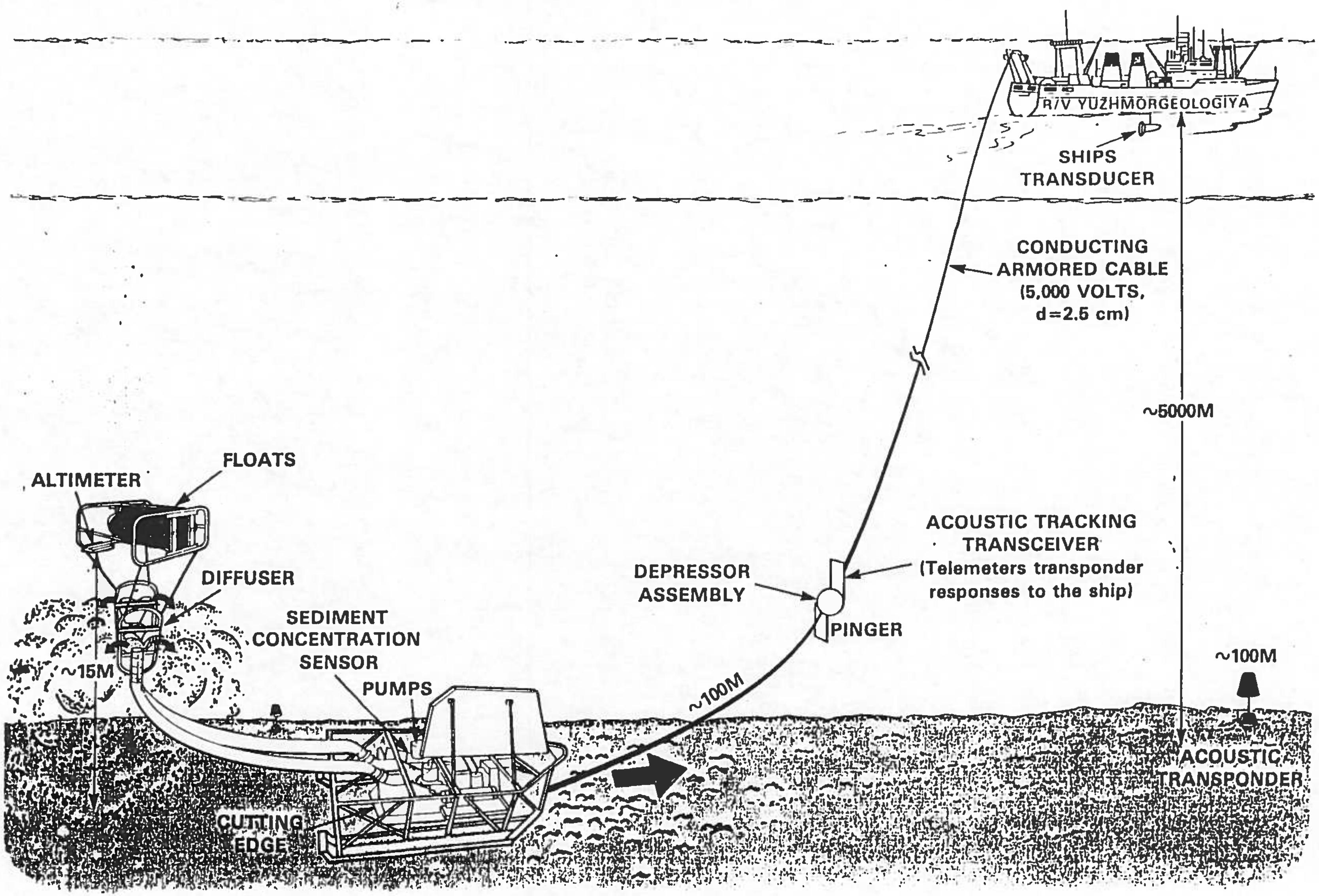

Figure 1. Conceptual design of the Deep Sea Sediment Resuspension System (DSSRS). The DSSRS is towed across the seafloor resuspending the top 10 cm of sediment. The DSSRS suspends bottom sediments using two 7.5 hp electric pumps powered through a 5000 V, 2.5-cm coaxial cable. The sediment is discharged 15 m above the seafloor dispersing over a 1-2 km^2 area.

the project was conducted under the leadership of Russian scientists aboard the R/V YUZHMORGEOLOGIYA. During this phase of the experiment current meters were recovered and deployed, a transponder net was deployed and calibrated, detailed information about the topography in the BIE area was collected using Russian sidescan sonar (Fig. 2), and TV/camera transects were made across the BIE site to assess manganese nodule coverage and megafaunal abundance and diversity (Fig. 3).

The third phase of the BIE project, which is the subject of this report, was conducted on July 17 - August 23, 1991. The two main goals of this phase of the project were to collect baseline information about the abyssal benthic community structure in the PRA, to create the actual resedimentation impact using the DSSRS, and to assess the extent of the resedimentation impact using both short and long lived particle-associated radioisotopes.

The fourth phase of the BIE project will assess benthic community disturbance resulting from various resedimentation thicknesses, and evaluate the spatial and temporal rates and patterns of community recovery following this disturbance. Post impact sampling cruises are currently planned for 6 months, 1 yr, 2 yr and 4 yr after the initial disturbance.

Cruise Goals and Objectives

Our primary goals on this Benthic Impact Experiment (BIE) cruise included the following:

1) Selection of a suitable experimental site based on bottom photographs and side-scan sonar records previously collected by our Soviet colleagues;

2) Collection of baseline (pre-disturbance) samples for macrofaunal, meiofaunal, microbiological and nodule-fauna studies (5-8 box core and 5-8 multicore samples);

3) Deployment of a sediment-trap array within the study area following analyses of current data from the current meters deployed on the previous cruise;

4) Creation of a large-scale (circa 2 km diameter) redeposition event by towing the Deep Sea Sediment Resuspension System (DSSRS) through a sediment-trap array for approximately 16 days;

5) Resedimentation mapping using the sediment-trap data (using sediment mass and Th-234 and Th-228 inventories), as well as thorium and x-ray analyses of multicore samples collected shortly after towing;

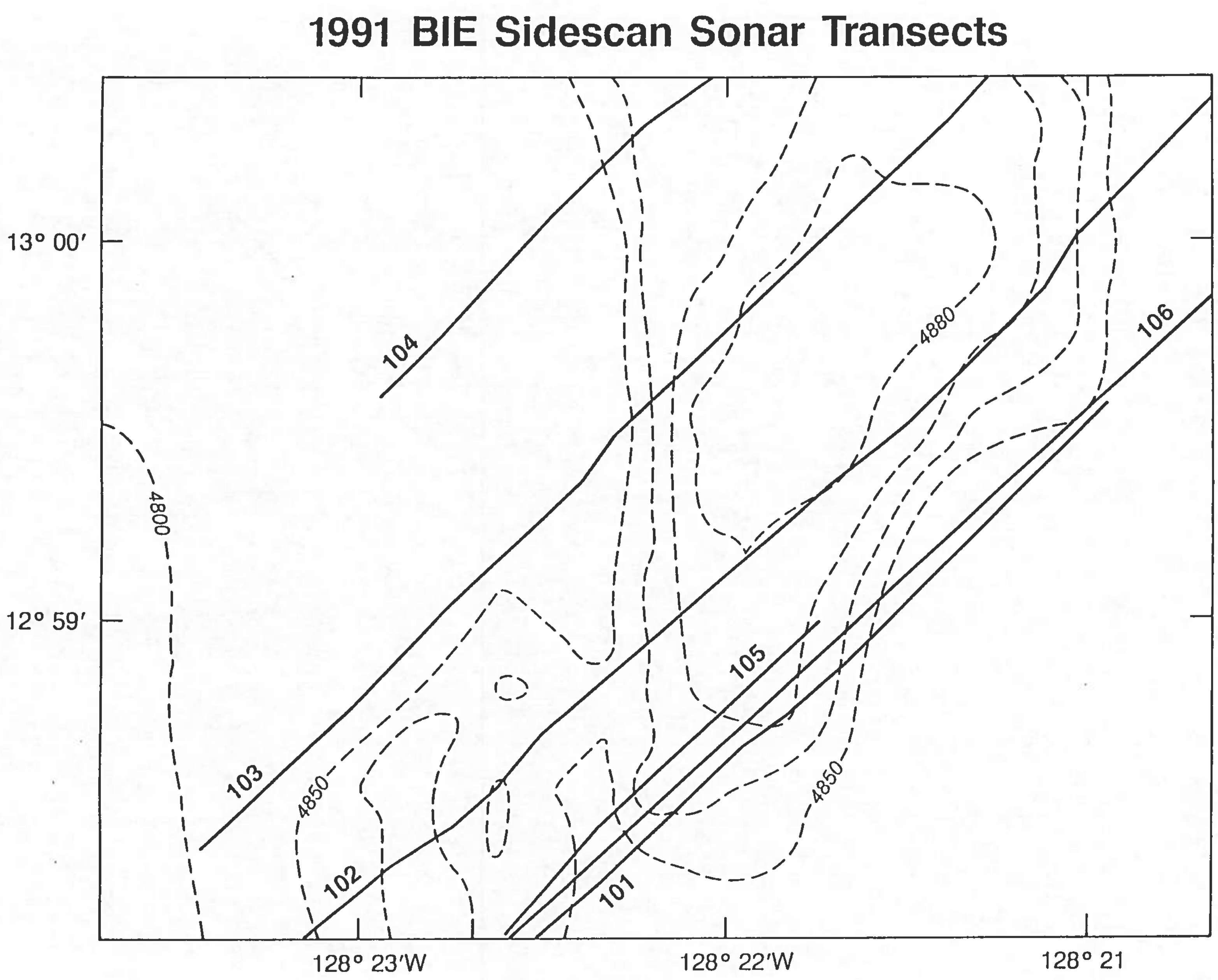

Figure 2. The position of sidescan sonar transects conducted during phase two of the BIE study, June 24 - July 14, 1991.

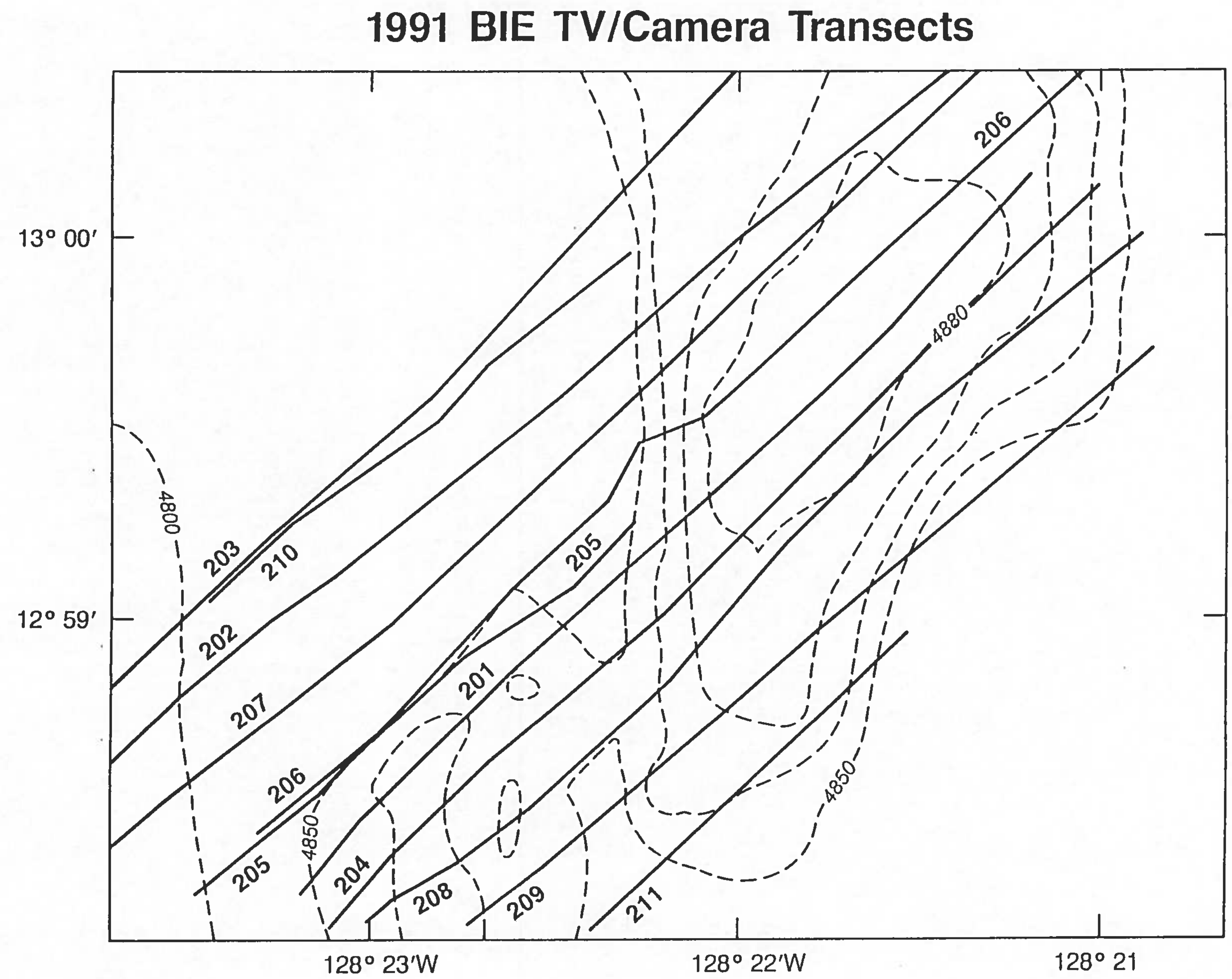

Figure 3. The position of television and photographic camera transects conducted during phase two of the BIE study, June 24 - July 14, 1991.

6) Collection, using the multicorer, of short-term post-disturbance samples for microbiological and meiofaunal impact studies.

Because of winch problems experienced while at the BIE site in the equatorial Pacific, a secondary goal in the final week of the cruise was to test tow the DSSRS for approximately 3 days in the Patton Escarpment test area, and to measure resultant resedimentation in an array of 5 sediment traps.

Cruise Summary

A. BIE Study Area

Site Selection. While in transit to the BIE study area (approximately 12° 59.5′ N, 128° 21.5′ W), we reviewed data from photographic and side-scan sonar profiles collected by the Soviets during the previous cruise leg. The basin centered at the above coordinates proved to be a sediment pond with zero to moderate nodule cover. For the focus of our studies within this basin, we chose a square 1.6 nmi on a side. Within this study area we (1) collected baseline samples at random points, (2) deployed the sediment-trap array, and (3) towed the DSSRS.

Baseline Sampling. In order to characterize baseline conditions in our experimental area, we collected nine 0.25 m^2 USNEL-type box cores and ten Barnett-type multicores (each consisting of eight 80 cm^2 tubes) of acceptable quality at random points within the area (Fig. 4). In addition, five multicores were collected after one tow run to determine whether the study area could still be considered pristine. Initially, some problems were encountered navigating the samplers into to bottom; for example, box core # 2 landed 1.6 miles from the desired sampling point. However, after some practice, the navigators were generally able to get the core samplers to within a few hundred meters of the desired sample location. The best success was obtained with the multicorer by lowering it to within 200 meters of the seafloor, stopping the winch while the ship maneuvered the core into position as indicated by transponder fixes within the Soviet- deployed transponder net, and then lowering the corer quickly to the seafloor. There were also some initial difficulties in obtaining good box cores and multicores because, to maintain steerage, the ship usually was moving about 0.5 kn over the bottom at the time of sample collection. Improved samples were obtained by increasing corer lowering speeds (to 30 and 70 m/min for the box corer and multicorer, respectively), minimizing multicorer time on the seafloor, and by requesting the ship to maintain position within 4-5 minutes of coring. We also had some difficulties recovering the box core without slamming it once or twice against the stern of the ship. Tag lines deployed from the

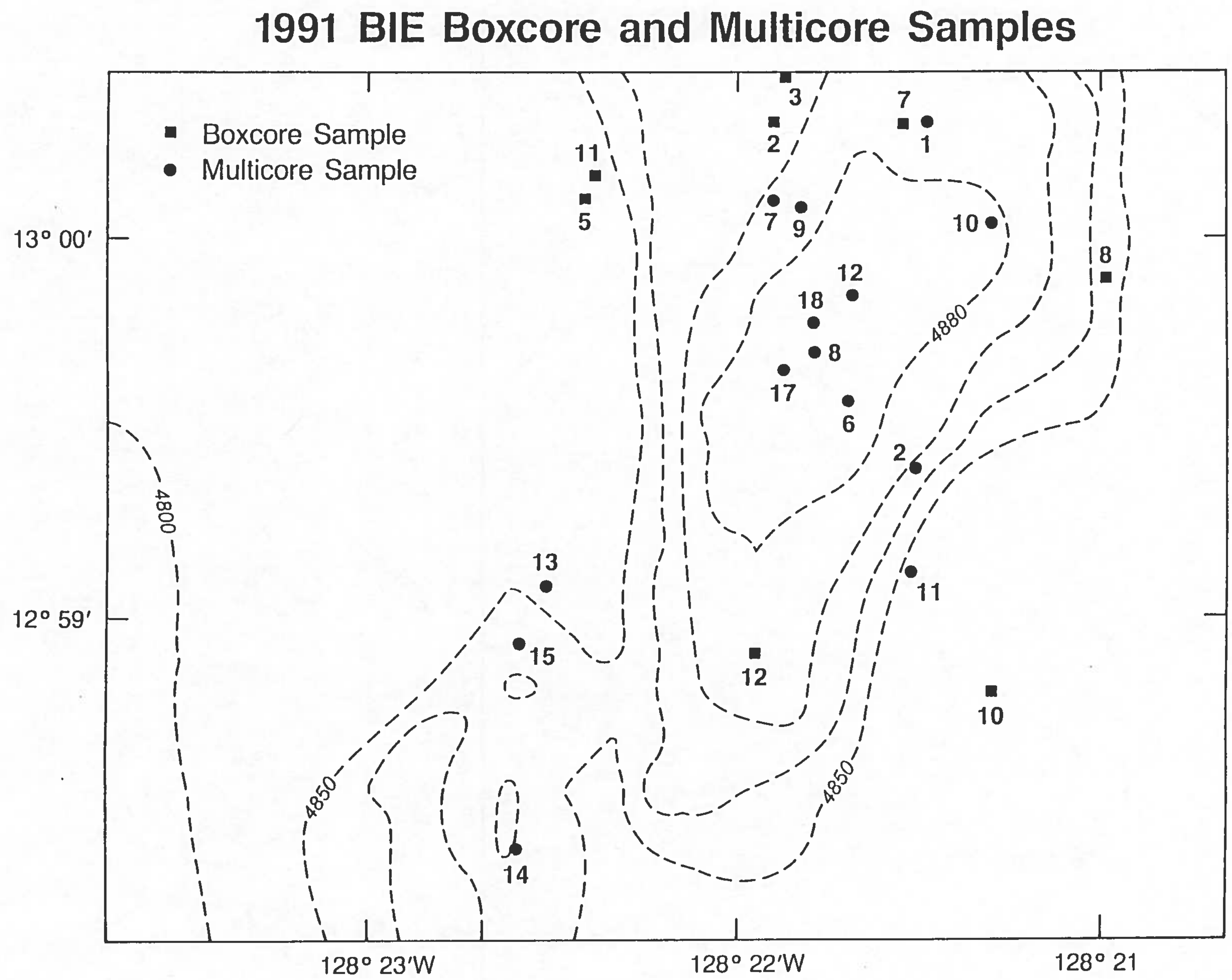

Figure 4. Location of box-core and multicore samples collected at the BIE study site during the July - August 1991 cruise. Boxe core 1 is not plotted; it's position was 13° 1.767′ N, 128° 20.977′ W.

ends of the two small stern A frames would decrease the trauma of corer recovery considerably on future cruises.

A summary of the baseline samples is as follows:

- Box cores 1, 2, 10 and 11 were subdivided in situ with one 10-x-10-cm subcore and two 10-x-2.5-cm x-ray meiostechers in the center. The boxe cores were processed for macrofauna (0-1 cm fixed whole, 1-5 and 5-10 cm layers washed on 300 micron screen and fixed) with subsamples removed from the central 10-x-10-cm subcore for radionuclide analyses (Pope) and microbiology (Dobbs). X-ray meiostechers were x-rayed and preserved for macrofauna as above.

- Box cores 3, 5, 7 and 8 were subdivided in situ into 22 10-x-10-cm subcores with the remaining 10-x-30-cm area containing two meiostecher subcores for x-ray analysis. Two of the 10-x-10-cm subcores from each boxcore were used for microbiology or radionuclide analyses. The remaining 20 10-x-10-cm subcores and open sediment from the 10-x-30-cm area in the box core was preserved for macrofauna as follows: 0-1 cm fixed whole in formalin, 1-5 and 5-10 cm layers washed on 300 micron screens and fixed. The meiostecher subcores were x-rayed, sectioned and preserved for macrofauna as above.

- Box core 12 was processed for macrofauna by Slava Melnik of the YUZHMORGEOLOGIYA.

- Multicores 1, 2, 5, 6, 7, 8, 9, 10, 11, and 12, collected prior to towing, or far from the tow path after the single successful tow, were processed for microbiology and meiofauna (Dobbs), radionuclides (Pope), porewater chemistry (Soviets), granulometry (Fukushima), sediment shear strength (Borowski) and macrofauna (Smith, Garner, Trueblood and Melnik). For details of protocols and tubes processed, see the Appendicies of this report or contact the above scientists.

Sediment Trap Deployment, Recovery and Preliminary Results. After completion of baseline sampling, 12 sediment-trap moorings and two sediment-trap-current-meter moorings were deployed around the planned disturber tow path (Fig. 5). Eleven traps were placed on the eastward side of the tow path, in anticipation of easterly near bottom currents (based on analyses of previous current meter data). The desired mooring pattern called for the tow path to pass through a 500-m wide gap in the mooring array; seafloor calibration of transponders on the moorings indicated that the gap actually was 360 m wide. The only problems encountered in trap deployments resulted from overlap in frequencies between Soviet and American transponders (Appendix 1); for the next BIE cruise, these frequencies should be changed in the American units.

Recovery of sediment-trap and current-meter moorings from the ship proved to be problematic; we thus used a whaleboat to tow moorings to the ship's side for attachment to a winch for haulout. Given favorable weather conditions, use of the whaleboat for sediment-trap recovery appears to minimize sample disturbance and mooring damage.

The results from the analyses of sediment trap contents following one successful DSSRS tow are outlined in Table 1.

DSSRS Towing. Because of a failure in the ship's main trawl winch, we only completed one tow of the Deep-Sea Sediment Resuspension System through the study area (Fig. 5). As outlined in Appendix 2, the DSSRS appeared to function properly, and the Yuzhmorgeologiya was able to successfully navigate along the desired tow path. However, turning the ship to bring the disturber to the beginning of the tow path appeared to take extremely long (8-12 hours). To allow adequate sediment resuspension within a reasonable time frame in the next BIE cruise, it would be very desirable to have a bow thruster on the YUZMORGEOLOGIYA. This should substantially reduce the time between tows through the study area.

Post-Impact Multicoring. After completion of the DSSRS tow, five multicores (numbers 13, 14, 15, 17 and 18) were collected to determine whether any detectable redeposition had occurred in the study area. After several trials and errors, we were able to sample within 100-200 meter of the presumptive disturber path. Preliminary multicore data suggest that there was no significant resedimentation at distances greater that 100-m from the tow path. Thus, it appears acceptable to use this site as our study area when we again attempt the BIE next year.

B. Patton Escarpment Test Area

After receipt off Long Beach of a replacement reduction gear for the broken winch, the ship's crew effected repairs and we proceeded to a site 9 hours from Long Beach (approximately 31° 31' N, 120° 14' W) for further testing of the DSSRS. After calibration of an existing transponder net, we deployed five sediment-trap moorings around the desired tow path. We subsequently collected three multicores in the area (numbers 19, 20 and 21) to evaluate baseline Th-234 and Th-228 inventories. Many of the multicore tubes contained 1 - 10 mm thick layers of phytodetritus. These multicores were processed for microbiological, pigment, porewater, and meiofaunal/macrofaunal analyses, as well as for radiochemical analyses.

Table 1. Optical backscatter measurements of sediment concentration and the corresponding deposition thickness for each sediment trap deployed in the BIE study area. Sediment concentration results are expressed as the mean ± 1 standard deviation.

Sediment Trap	Sediment Concentration (mg/l)	Deposition Thickness ($\mu m/cm^2$)
1	13.37 ± 4.12	9.08
2	11.72 ± 7.43	7.96
3	32.34 ± 16.50	21.97
4	27.39 ± 16.50	18.61
5	-	-
6	26.57 ± 14.03	18.05
7	41.42 ± 15.68	28.14
8	25.74 ± 3.30	17.49
8A	23.27 ± 0.82	15.81
9	19.14 ± 6.60	13.00
10	19.14 ± 8.25	13.00
10A	7.59 ± 1.65	5.16
11	-	-
12	1.82 ± 2.48	1.23

1991 DSSRS Tow Path and Sediment Trap Array

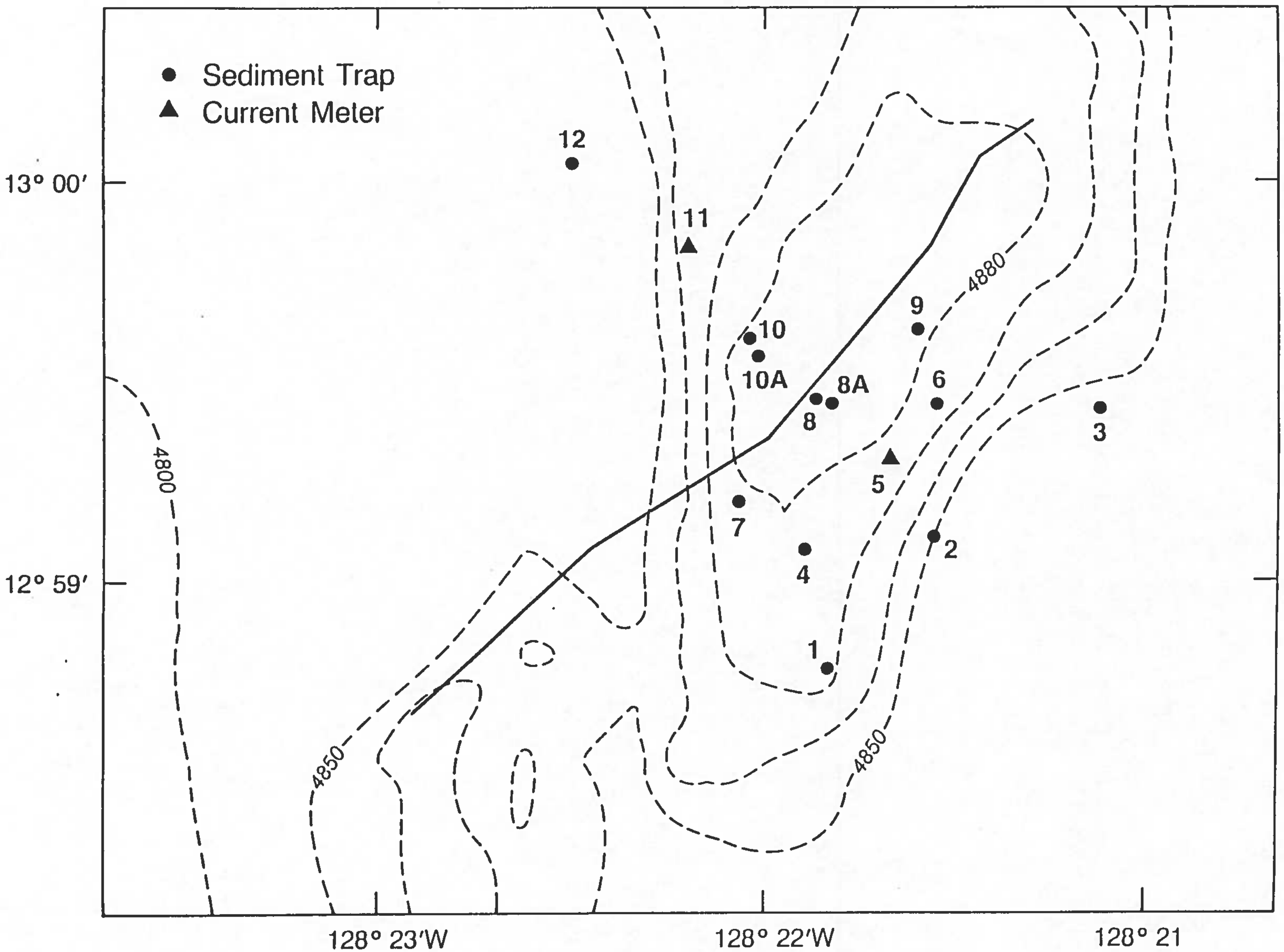

Figure 5. Location of the sediment traps, current meters and DSSRS tow path in the BIE study area.

Following collection of three multicores, we were able to conduct one complete, and one abbreviated, tow with the DSSRS through the study area before the winch failed permanently (see section by Petters and Wilson). Again, the DSSRS performed well and we were able to tow into the wind with acceptable accuracy. Once again, however, turning times were extremely long.

After winch failure, the YUZMORGEOLOGIYA crew recovered the DSSRS unscathed by transferring the coaxial cable to another winch. This operation was complicated and dangerous; the ship's personnel are to be highly commended for an outstanding job.

Following DSSRS recovery, we collected one more multicore (number 22) in the area, to further document the phytodetritus signal at the seafloor. This multicorer was processed in the same manner as the three previous multicores from this site. We then headed into Long Beach for the final port call of the cruise.

Recommendations for Cruises in 1992

A. Technical requirements

While the present technical capabilities of the YUZMORGEOLOGIYA allowed us to perform a number of tasks acceptably (e.g., box coring; multicoring; launch and recovery of sediment traps; launch, recovery and straight-line towing of the DSSRS), technical improvements to the YUZHMORGEOLOGIYA are strongly recommended for successful completion of the next BIE cruise. These improvements are listed below:

1) A new, stronger winch.

2) A powerful bow thruster.

3) A high-quality 25-mm coaxial cable.

4) A tension monitoring system for the 25-mm cable.

5) An improved acoustic navigation system.

6) Larger diameter blocks for the 1/2 inch American cable used for box and multicoring.

7) A test cruise, prior to the next BIE cruise, in water deeper than 4000 m (preferably not far from Gelenzhik so that any necessary modifications can be made easily).

The rationale for each of these technical items is detailed in the attached reports by Sessions and by Petters and Wilson.

B. Personnel Requirements

During the first BIE cruise, the Soviet crew and scientists aboard the YUZMORGEOLOGIYA proved to be exceptionally capable and hard-working. To preserve continuity in scientific and technical operations, it would be extremely beneficial to have a number of key personnel return next year.

For all of our deck, towing and coring operations, we regard the scientific deck chief Lyaskovskiy Oleg and his entire crew to be essential. Also essential to the success of our program are the transponder-navigation specialists Shevelev Evgeniy and Chuprinin Ivan. Towing operations were facilitated by the expertise and English-speaking capabilities of Prokhorov Vladimir. In addition, Akhakov Boris, the chief mate, was extremely useful to our program because of his familiarity with our launch and recovery operations, as well as his good English. Finally, the excellent English and scientific cooperation of Pilipchuk Mikhail and Melnick Vyacheslav proved very helpful to our program. We request that all these people be included next year in the YUZMORGEOLOGIYA shipboard personnel.

It would also be extremely useful to have a English-Russian translator, like Katja Ershova, that is well versed in scientific and technical translation.

Appendix 1

BIE 1991 Technical Cruise Results

by

Meredith Sessions
Scripps Institution of Oceanography

Experience gained during the June 1991 test cruise and the BIE-91 cruise have disclosed a number of operational and technical details which must be corrected in order to conduct a successful experiment. Fundamentally we have demonstrated that it is possible to launch, tow and recover the Deep Sea Sediment Resuspension System (DSSRS), navigate it through a field of sediment traps and current meters and that it suspends a consistent quantity of sediment. We have also shown that box core and multicore sampling can be done reliably from the aft trawl winch on 0.5 inch diameter 3X19 wire in 5000 m depth.

Based on the experience of the first BIE cruise we have determined that the following items are necessary to insure a subsequent successful cruise:

1. A new stronger winch.
2. A powerful bow thruster.
3. A good quality 25 mm coaxial cable.
4. A tension monitoring system for the 25 mm cable.
5. An improved acoustic navigation system.
6. Larger diameter blocks.
7. A Russian Translator.
8. A test cruise prior to the BIE cruise.

These items are all discussed in detail below.

Unfortunately the second idler gear in the coaxial cable winch drive transmission failed during deployment of the DSSRS with approximately 1500 m of wire out during the second tow. This effectively ended the resuspension portion of the BIE. Subsequent attempts to spool the 25 mm coaxial cable onto the port trawl winch and rig the small A-frame to tow the DSSRS were unsuccessful. Calculations of static winch torque showed that according t published specifications the winch was not overloaded by this task and the cause of the gear failure remains a mystery. Later it was learned that this gear had failed in other identical winches which and allow for an altimeter channel. I feel this should be accomplished prior to the next BIE cruise.

The American acoustic system for releasing and ranging to sediment traps did not work at all due to poor tow fish configuration. This problem was overcome by patching between our command system and the Russian tow fish. For the next cruise it is recommended that a new American tow fish configuration be acquired and a winch and davit provided on the ship for its use. There also existed a very bad acoustic frequency conflict between several American and Russian uses which must be corrected by changing the American acoustic release transmit and receive frequencies. Since it is vital to calibrate the position of a number of sediment traps close to the tow path frequency selection must be carefully coordinated for this purpose.

Communication between the acoustic navigation laboratory, surface navigation laboratory, bridge and the deck operations was a continuous source of problems for our operations. This needs to be much improved to fully and efficiently utilize the capability of the ship. We used three small hand held radios for some improvement in operational communication, but it did not overcome this problem entirely. Lack of functioning remote readouts of parameters such as ship speed and wind speed and direction in the acoustic navigation lab where critical ship maneuvering decisions had to be made severely restricted timely operations.

While a Russian speaking NOAA officer accompanied us to help with translation, the lack of an English speaking Russian translator with a scientific background at times caused confusion. For the next BIE cruise it would be most helpful if such a person could be included with the crew.

During this 1991 BIE experiment and the two test portions of cruises we have worked closely with several key personnel who we consider to be critical to the success of our future work. They have learned the details of our operations and have gained valuable experience and skills in these tasks. The successful completion of our research relied on their performance and knowledge during this cruise. It is requested that these key people participate in the next BIE cruise. These people from the science party are Oleg Lyaskovskiy and his deck crew, Evgeniy Shevelev, Ivan Chuprinin and their group. Additionally we include from the ship's crew Chief Mate, Boris Askhakov.

From the above experiences I feel it is essential to conduct an adequate test cruise prior to the next BIE experiment. This test cruise must fully evaluate all critical phases of the proposed work. This should include winch performance, ship maneuvering characteristics while towing in various wind and sea conditions and coaxial cable mechanical performance under expected operating loads. Cable tension must be monitored during these tow tests.

suggest inadequate design of manufacture. In any case it is clear that this winch is not up to the task of DSSRS towing and must be replaced with a more reliable unit.

An attempt to repair the winch at sea with a gear sent over from the Soviet Union failed after one tow as the drive shaft to the winch the replaced gear was attached broke. This may have been related to the fact that the gear as received was bent and required straightening after installation in the gear box. We had the gear pressed onto the drive shaft with a large hydraulic press at a machine shop in Long Beach as this type of equipment was required, but no available on the ship. The engineering crew os the YUZHMORGEOLOGIYA are to commended for their extraordinary ingenuity and skill in accomplishing the at sea repairs even though they were ill equipped for this task.

It was discovered very early in the test cruise that the 25 mm coaxial cable had at least on defective wire strand in the outer armor jacket. These broken wires occurred at approximately 7 places along the length of the cable and required constant repair by overwraping with stainless steel safety wire. This drastically increased the time for spooling wire on and off of the main winch. This cable must be replaced with a fully tested one and I suggest that a spare cable should be carried aboard the ship for future cruises. It was also discovered during the test cruise that the sheave diameter for the main block was smaller that the one used last year for the 20 mm coaxial cable and this may have aggravated the wire failure. We subsequently found the old 20 mm wire block and had the sheave machined in Long Beach, California to accommodate the 25 mm diameter wire. For the next cruise a more reliable winch which can withstand our towing loads must be supplied. Also a suitable large diameter block and a method to measure wire tension while towing should be used with this winch.

The box coring and multicoring operations from the starboard trawl winch worked well, but required that the 12.7 mm wire had to be turned over three blocks which were too small in diameter for good wire fatigue life. These must all be increased in diameter to a minimum of 0.7 m for future work to provide acceptable wire life.

The Russian ASMOD acoustic navigation system worked very well during both the testing and operational phases of the cruise. It was learned during the experiment that it was necessary to calibrate acoustically the positions of a number of sediment traps. The only limitations encountered were long times required to survey in these sediment traps and transponders. Also having only four channels in the subsurface relay transponder system limited the area coverage for navigation. These situations can readily be corrected by modifying the calibration software to allow for the simultaneous calibration of more than one transponder and the addition of several more channels. This would save considerable ship time, greatly improve the area coverage of bottom navigation

The tests should be carried out in deep water (4000 m minimum) where the stresses of towing and maneuvering performance of modifications are realistic. It is also important to conduct these test close to the home port of the ship so that any problems detected (e.g. winch cable winding difficulties) can be corrected in a timely manner.

Appendix 2

Preliminary BIE Deep Sea Sediment Resuspension System
Test Report and Recommendations for Future Tests

by

Richard Petters & Dave Wilson
Williamson and Associates, Inc.

During the 40 day BIE cruise, three bottom tows of the Deep Sea Sediment Resuspension System (DSSRS) were made. One tow at the BIE site, and two at the Patton Escarpment Test Area. Total run time for the DSSRS, excluding check out tests, was 27.5 hrs and total time on the bottom pumping sediment was 6.25 hr. At this time we have no reason to believe that the DSSRS was not functioning properly during these operations.

Although the number of tows was far less than what was originally envisioned, a lot of useful information can be obtained from this cruise regarding DSSRS performance, shipboard operations and equipment.

DSSRS Performance

Sensor data recorded during operation of the DSSRS and post test inspection indicates that the DSSRS was suspending sediment at a rate, which when adjusted for ship speed, is theoretically what would be expected.

On tow 1, data from the optical backscatter sensor (OBS) are very close to what predicted values should be, given the width, depth of cut, and speed of the DSSRS. At the tow speed of 0.6 kt, the throughput rates averaged approximately 75 g/l. At the design tow speed of 1.5 kt (almost 3 times the actual tow speed), the throughput rate would be 200 g/l. The differential pressure sensor also recorded an increase in pump pressure when pumping sediment. These data have not been analyzed and compared to theoretical values.

Visual inspection after the test showed wear and impact marks on the discharge nozzles at the top of the riser from the flow of sediment and nodules. Resuspended sediment was also found in the sediment settling traps mounted on the sled. Two large pumice stones were found in the intake of the starboard pump. We believe that these stones were wedged through the side of the intake duct because the front face of the duct was covered by a grid of rods with a 1 inch separation between the rods. Shields were placed on the sides of the intake ducts to prevent this from occurring again.

With the exception of a riser hose which became disconnected during the first deployment due to excessive bending during launch, the riser hose and float frame performed as designed. A change in the rigging of the riser hose solved the bending problem. An altimeter mounted on the float frame indicated that the discharge nozzles were at an altitude of approximately 22 m above the seafloor during the tow. A design height of 18 - 20 m was expected at a tow speed of 1.5 kt.

A hockle did occur in the tow cable approximately 3 m up the cable from the DSSRS. This is the only hockle observed during the operation of the DSSRS, including tows made during the June test cruise. We believe the hockle occurred because of slow ship speed and interaction between the DSSRS and undulations in the seafloor which are reported to occur in this area.

Further operations in the BIE test area were discontinued due to a failure of the main tow winch and resumed at the Patton Escarpment test area off of Long Beach, California after replacing the failed gear.

Data from tows 2 and 3 at the Patton Escarpment test area have not been extensively analyzed. Sediment concentrations on tow 2 started out initially at 80 to 120 g/l with tow speeds ranging from 0.7 to 1.0 kt. Later in the tow the discharge concentration dropped to 70 g/l. A similar trend occurred during the tow in this area on the June test cruise. A possible explanation is a change in bottom character. Multicore samples taken in this area indicate that the bottom is much more consolidated than the BIE study area.

A third tow in the test site was attempted. It was a downwind tow (not of our design) and had to be abandoned shortly after touchdown because of poor positioning of the ship and DSSRS. The ships speed over ground was high (1.7 kt) and an additional 1100 m of cable had to be payed out to get the DSSRS on the seafloor. Whether this additional cable scope was due to the higher tow speeds or subsurface currents is not known. The third tow attempt was eventually abandoned due to a broken shaft in the winch gear box. As in the previous tow in this area, sona bouy wire was found in one of the pumps.

Recommendations for the Next BIE Cruise

DSSRS. The DSSRS has two pumps and discharge hoses. Both should be fully instrumented with pressure transducers and optical backscatter sensors. Additionally, consideration should be given to installing a magnetic flux sensor for direct measurement of the slurry flow rate. Additional information which would be useful is subsurface volts and amps.

The intake nozzles need to be modified so that they respond quicker to the undulations in the seafloor which occur in the BIE area.

A speed log would be useful on the sled as changes in ship speed take a while to show up on GPS, and data from the acoustic net is questionable during a poor set of fixes.

Shipboard Operations. Launch and recovery of the DSSRS was handled very well by the deck crew led by Oleg Livkosky. Their successful effort to recover the DSSRS after the winch failed during tow 3 was amazing and could only be accomplished by a group of people that works well together. We advise that this deck crew be involved in the next BIE cruise.

Communication between the various departments in the ship needs to be improved. For example, during the towing operations instructions between the acoustic navigation room, ship's navigation room and the bridge would get lost. For the next cruise, it would be advisable to put all the groups in the same room. Additionally, a monitor in the winch room that displays the depth, altitude, pitch, roll, and heading of the DSSRS is recommended.

Tow Cable. A new tow cable will be needed now that the old one is cut. We advise that the new cable should be constructed so that it is at least as good, if not better, than the old cable electrically, and it should have a higher breaking strength. During the BIE, static loads on the cable were almost 1/2 the breaking strength of the cable. This ratio should be about 1/3.

Winch. A new winch is also needed and should be well tested along with the cable to insure that it level winds properly and that the traction winch, if used, does not put any twists in the cable or distort the cable's armor.

Ship Handling. Control over the ship was better than expected during the low speed straight line tows. However, the addition of a sizable bow thruster should improve the upwind turning ability of the ship and steerage during tows in bad weather. The bow thruster may also reduce the amount of time required to complete a tow track of the DSSRS.

Test Cruise. If the above changes are made to the ship, it is imperative that another test cruise be conducted to check out the functional reliability and compatibility of all components of the two system, i.e. ship, winch, cable, DSSRS, etc. This cruise should also take place at a local where repairs can be readily made. The test should be set up with a long vase line navigation system so that the tow characteristics of the entire system can be monitored. Additionally, tow tension on the cable should be measured.

BIE-2 Test. The nest BIE cruise schedule should allow for at least 5 days of down time for weather and/or equipment repairs. Had the winch not failed, hurricane Fefa would have run us out of the BIE site for at least that many days.

Appendix 3

MICROBIOLOGICAL SAMPLING ON THE BIE 91 CRUISE

by

Dr. Fred Dobbs
Dept. of Oceanography, University of Hawaii

I have organized description of the microbiological samples according to sampling device, i.e., box core or multicorer. From each, collections were made to quantify microbial biomass (lipids and ATP), characterize microbial community structure (lipids), and quantify sedimentary labile protein. I consider microbial biomass and labile protein as potential food resources for deposit-feeding macrofauna, the dominant trophic group at the BIE site. Knowledge of the amount and vertical distribution of food for deposit feeders, and comparison of samples taken before and after disturbance, will provide insight into the potential effects of deep-sea mining of manganese nodules.

BOX CORES: Samples were taken from three box cores prior to the disturber's operation. From each box core, seven sub-cores were taken with modified syringes (inner diameter=3.5 cm) from a single vegematic partition (10 x 10 cm) fastened in the box core before lowering. Cores were extruded and samples for lipids and protein were taken at the following horizons: 0.0-0.5, 0.5- 1.0, 1.0-1.5, 1.5-2.0, 2.0-2.5, 2.5-3.0, 3.0-3.5, 3.5-4.0, 4.0- 4.5, 4.5-5.0, 5.0-6.0, and 9.0-10.0 cm. Samples were homogenized in a petri dish, placed in plastic bags, and quickly frozen in liquid nitrogen. They will be transported to my laboratory in Hawaii for further processing. In addition, samples for ATP (adenosine triphosphate) were taken at the following horizons: 0.0-0.5 cm, 1.0-1.5 cm, and 2.0-2.5 cm. These samples were placed into 0.5 N sulfuric acid (H2SO4) and refrigerated. As above, these samples will be transported to my laboratory in Hawaii for further processing.

MULTICORES: Samples were taken from four multicores (inner diameter=9.5 cm) prior to the disturber's operation. Sediment was collected at 0.5-cm intervals (see above), homogenized in a petri dish, sampled for lipids and protein, and frozen in liquid nitrogen. Samples for ATP were taken as described above.

Similarly, after the disturber's operation, three multicores were sampled as described above.

COOPERATIVE EFFORTS: From the majority of cores sampled for microbiology or meiofauna, the Soviet microbiologist Vitaly Zaporoshchenko took samples for manganese and iron bacteria from three horizons: 0 cm (i.e., the sediment- water interface), 5 cm and 10 cm.

ENRICHMENT OF BAROPHILIC BACTERIA: Sediment was collected and enrichment cultures were made for barophilic bacteria. Sediment samples (1-2 ml) were added to two media, sterile seawater and sterile seawater containing peptone (0.01%). These enrichments were heat-sealed in plastic bags, pressurized to 7,100 pounds per square inch (equivalent to a depth of 4880 meters), and kept in the refrigerator prior to shipment to Hawaii for further processing. The ultimate goal of this effort is to isolate strains of barophilic bacteria for investigations of their DNA. Fred Dobbs 14 August 1991

Appendix 4

MEIOFAUNAL SAMPLING ON THE BIE 91 CRUISE

by

Dr. Fred Dobbs
Dept. of Oceanography, University of Hawaii

MEIOFAUNAL COMMUNITY STRUCTURE: Eight multicores, all collected before the DSSRS operated, were sectioned for meiofaunal analysis as follows: topwater, 0.0-0.5, 0.5- 1.0, 1.0-1.5, 1.5-2.0, 2.0-2.5, and 2.5-3.0 cm. Each horizon was separately fixed in formalin (10%) and will be sent to and analyzed by Prof. David Thistle, The Florida State University, Tallahassee, Florida, 96822, USA. Comparison of these pre- disturbance samples with post-disturbance samples will indicate the degree of disruption to the meiofaunal community caused by redeposition of sediment.

MEIOFAUNAL LIPID RESERVES: Samples for meiofauna were collected, at intervals described above, from four multicorer samples taken before the DSSRS operation. However, rather than being fixed in formalin, these samples were quickly frozen in liquid nitrogen. They will be shipped frozen to Prof. David Thistle (see address above). He will pick out the harpacticoid copepods from the sample and quantify their lipid content. Comparison of these pre-disturbance samples with post-disturbance samples will suggest the copepods' level of nutritional stress caused by redeposition of sediment. If the vertical distribution and lipid content of the copepods does not change following disturbance, then redeposition will be considered to have little effect. If lipid content decreases, then starvation will be indicated.

Appendix 5

X-ray and Photography of Meiostechers from Box-Core and Multicore Samples

by

Shawn Doan
Dept. of Oceanography, University of Hawaii

Meiostechers (clear, plastic, 2.5-cm thick cores with sliding bottom doors) were photographed and x-rayed to document burrow structure, redeposition layers, and the possible entombment of animals. Meiostechers were attached directly to the boxcorer so that the boxcore and meiostecher samples were taken concurrently. Once the boxcore was on deck, doors were inserted into the meiostechers; meiostechers were then excavated and carried to the ship's lab for photos and x-rays. The procedure differed for multicore sampling because the meiostecher sample was taken from a subcore after the multicorer was on deck. A subcore designated for x-ray analysis would first be photographed intact, and then extruded, with the meiostecher being inserted during extrusion and then removed to the lab for photos and x-rays.

Every meiostecher and every multicore tube that was subcored with a meiostecher was photographed at least twice, front and back shots. Additional photos were taken if any interesting structures or organisms were present.

Kodak Industrex AA x-ray film was used for all x-rays with two x-rays taken for each meiostecher. Experimentation with exposures showed that details of deeper and denser sediment are best brought out with a 16.3 second exposure and a standard development time, while a 14 second exposure and 3 minutes added to the standard development time heightens the image contrast of low density redeposition layers. All exposures were taken at 15 amps and 70 kilovolts.

The photography and x-ray procedure could be improved by the use of a macro lens for the photography of small details, relocating the x-ray lab so that there will be a shorter transport distance and less opportunity for disturbing the sediment/seawater interface between the working deck and the lab, anchoring the meiostechers within the multicore tubes so that meiostecher and multicore sampling will be simultaneous, and redesigning the meiostecher x-ray stand so that it holds the meiostechers more firmly, holds the x-ray film against the meiostecher without the use of electrical tape, and is easier to clean.

Appendix 6

Sediment Trap Processing and OBS Protocol

by

Dr. Dwight D. Trueblood
NOAA, Ocean Minerals and Energy Division

After each sediment trap was brought on board, the samples were taken to the lab and secured in an upright position. The top plastic caps, which were placed on top of the traps before they were recovered to avoid sample loss, and the baffles were removed and the traps let stand for 30 min.

Each trap was then viewed with the aid of a flash light. If the bottom of the trap was totally covered with sediment, the trap was used for Th^{234} analysis. If not, the top water was siphoned off using a piece of latex tubing. All water, except for the final 500 ml was siphoned off into a 10 gal cubitainer. The remaining water and sediment was swished around and poored into a 1 l nalgene beaker. The bottom of the trap was then washed again with 20 ml of seawater to remove any remaining particles.

Since siphoning water didn't always remove all but 500 ml of water, the water-sediment suspension was adjusted to 500 ml vol either by adding water from the samples cubitainer or pooring water off the sample into the cubitainer. The water was then transfered into a 600 ml nalgene beaker and agetated using a stir plate set at setting number 5. The OBS probe was then placed into the sample and a voltage reading taken using the 2.5 V scale on the voltage meter.

After the OBS reading, the sample was transfered into the sample's corresponding cubitainer. The cubitainer was shaken and 1 l filtered onto a 0.45 μm, preweighed nucleopore filter. The filters were then placed in individual vials and later dried and weighed to obtain the particulate weight per unit volume. The sample was then measured quantitativily for its total water volume. This procedure was repeated for each trap replicate.

Appendix 7

USA Scientific Party

Chief Scientists	Affiliation
Dr. Craig Smith	University of Hawaii
Dr. Dwight D. Trueblood	NOAA/ Ocean Minerals and Energy

Scientific Team	
Mr. Craig Baily	NOAA
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Ms. Susan Garner	Scripps Institute of Oceanography
Ms. Victoria Rectenwald	Texas A & M University
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